Space Weather Technical Forecast

Issued on Friday, 23 September 2022 at 13:07 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Lowered Chance of G1 at first, but increased later in four days due to possible CME arrival(s). Daily Chance of R1, brief Chance of Active electron fluence over UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity measured at L1 by GOES16 and 17 has been Low, with a slow undulation in background X-ray flux in low C-class, interspersed by more sizeable mid-C-class activity. The peak of these flares was a late, possible CME-producing C7.2 at 23/1133UTC from a new region on the northeastern limb; else being a C6.0 at 23/0339UTC, with this appearing to emanate from AR3107 in the southeastern quadrant. This group appears as a stable Cho/Beta, but with a large span of 13 degrees solar longitude, and several small spots at low latitudes. This group was one of up to six on the current disc, with the areally larger AR3105 to its immediate northwest, with a complex designation of Dkc/Beta further added to by a candidate for an emerging Mt Wilson delta spot later in the 24 hours, although at the time of writing this was not capped by any activity increase. A new region appeared on the northeastern limb in the period, while AR3109, AR3108 and AR3102 were all more stable, with AR3109 showing only gradual trailing spot emergence.

Coronagraph imagery in the period was dominated by a large, wide-angled but apparently slow partial halo Coronal Mass Ejection (CME), first visible from late morning UTC on 22 September in Lasco C2. This CME has been analysed at length and is now thought likely to be related to the then-rapid emergence of AR3109 - probably from one of the attendant coronal dimmings observed in AIA 211. Of these dimming, the CME perhaps most likely left the disc around the dawn period UTC on 22 September. The latest MOSWOC Enlil run puts arrival of this feature around 26/0100UTC, i.e. the turn of the UTC day Sunday 25 September into Monday 26.

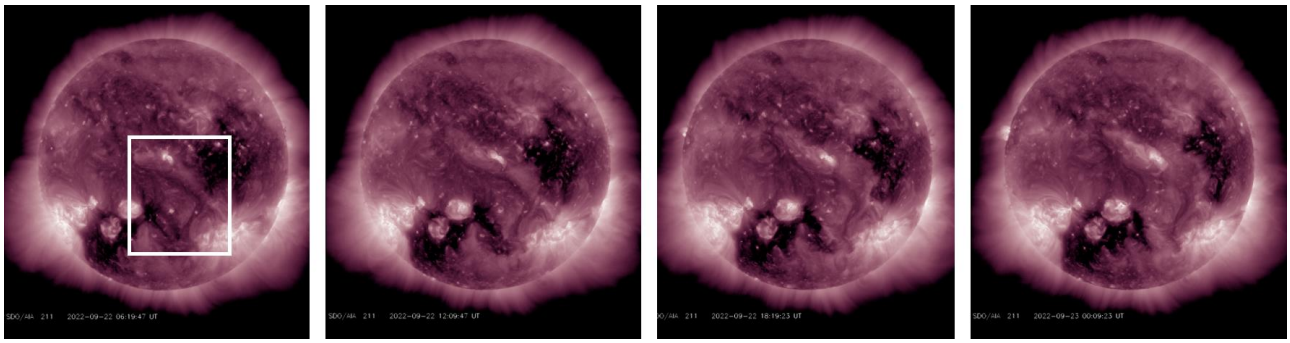

Figure 0: Six-hour cadence time sequence of AIA 211 showing a retrospective potential 'filament channel-like' feature bisecting coronal holes 25 and 26, extending to the southwest of emerging AR3109 (centre-disc). This is a speculative attribution for the CME seen heading mainly north and west of the Sun-Earth line through the UTC day of 22 September. MOSWOC Enlil modelling has this feature's potential arrival around 26/0100UTC.

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An earlier faint CME from the southeast disc on 21 September should (narrowly) maintain its independence as a resolved feature, perhaps arriving as a glancing blow just ahead of its sibling later on 25 September. Both events carry low confidence, but are the only CMEs in the forecast at present.

A small filament was seen to leave the southwest disc at low solar latitudes around 22/1500UTC, however this did not appear in subsequent coronagraph imagery and has likely been re-absorbed.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1, was of uncertain character, with SSBC(s) in evidence, but perhaps also the fast wind from coronal hole 25, with lower intensity than expected, and more tenuous connection.

The solar wind speed exhibited a slow decline at first in the 24 hours, but showed a discontinuity and subsequent rise from 22/1700UTC, with a further jump at 22/2100UTC to a peak of 450km/s. Following this, an overall decrease was observed, but with an erratic character. The solar wind density was variable, peaking near 20ppcc immediately before the main speed increase, perhaps a very brief CIR or SSBC, repeating around 23/0130UTC before an ensuing decline into single figures. The IMF peaked at Slightly Elevated levels through the middle of the reporting period, attenuating slightly into the current UTC day. The north-south component, Bz, showed a different character before and after 22/2100UTC: being small-scale and variable ahead of the change; and larger magnitude with a slow oscillation into Friday 23 September, with a range of +/-7nT. The phi angle was changeable before 22/2100UTC, being more reliably positive afterwards (away from the Sun), but still with some forays into negative orientation, especially after 23/0900UTC.

The net result of the above solar wind measures was for provisionally Quiet to Unsettled Kp, peaking at 3+ in the 06-09UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16, remained very close to Background levels on a downward trend.

High energy electron flux (greater than 2 MeV) was at Normal Background to Moderate levels, with peak value 867 pfu at 22/2145 UTC. The associated 24-hour fluence remained well below the Active (1e8 integrated pfu) threshold. Observed fluence at 23/0001UTC was 1.18e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be Low to Moderate, with further C-class flares Expected and a with an ongoing Chance of M-class flares. The main flare risk remains from AR3105 and AR3107 in the southeastern disc.

Solar Wind / Geomagnetic Activity: This forecast period comprises an imminent or possibly current coronal hole fast wind (from CH25/+), and up to two low confidence CMEs on days three and four (Sunday 25 and Monday 26 September). For a full discussion of this, please see the Geomagnetic Activity section, however the upshot is a peak Chance of G1 in the next 24 hours and again between the UTC days of 25 and 26 September, else falling to a Slight Chance.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES16, is expected to persist at Background levels.

The high energy electron flux (greater than 2 MeV) is expected to be at Background to Moderate levels at first, probably rising in response to CH25's fast wind for a time over the UTC weekend. Later in the four days, either or both of a pair of CMEs may again attenuate counts at GEO to lower the risk of prolonged exceedence of High flux.

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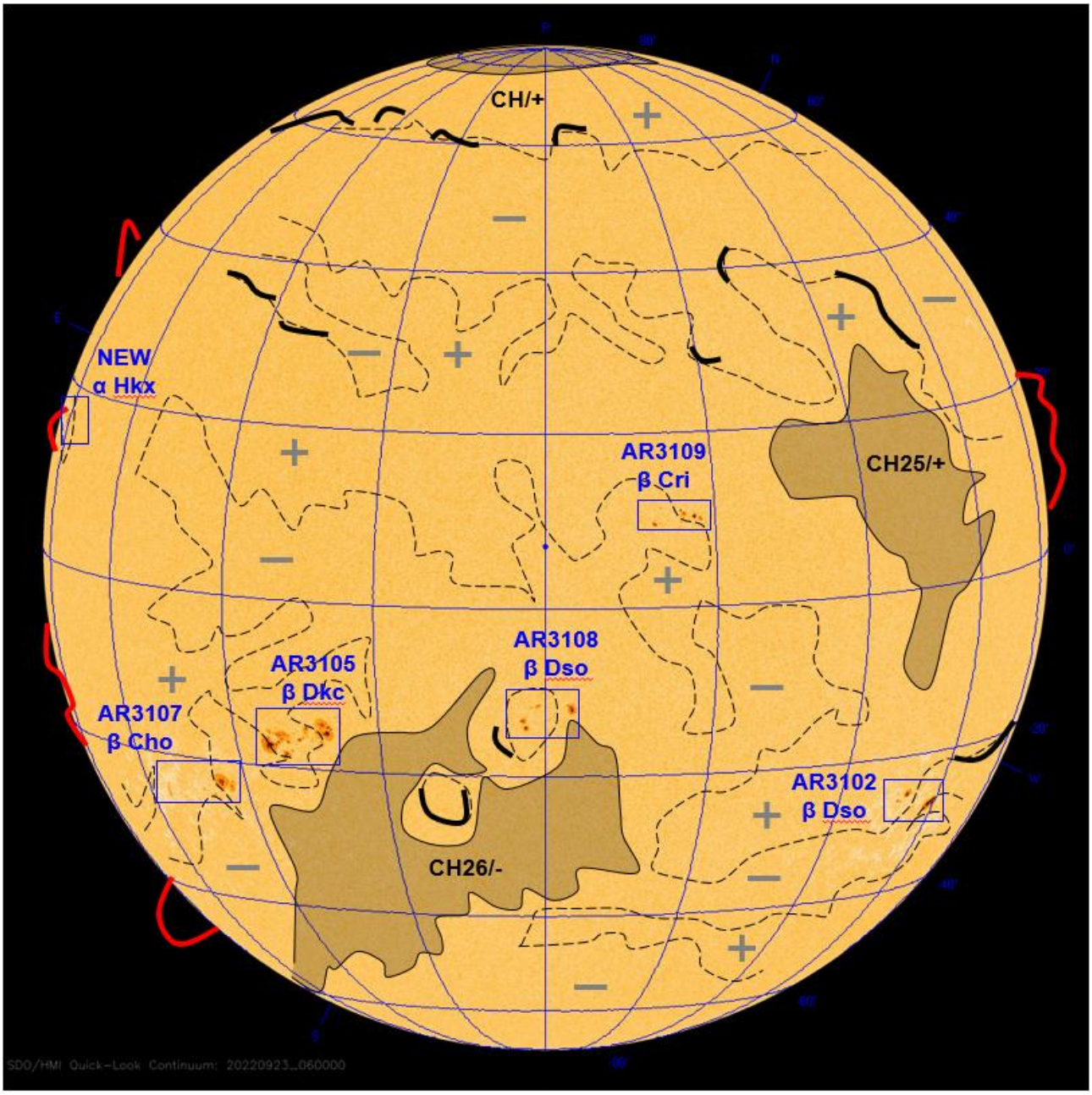
The associated 24-hour fluence is expected mainly to stay below the Active (1e8 integrated pfu) threshold, but perhaps showing a Chance of approaching this for a time over the UTC weekend.

Figure 1. Solar Analysis Valid 23/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

This forecast period comprises an imminent or possibly current coronal hole fast wind (from CH25/+), and up to two low confidence CMEs on days three and four (Sunday 25 and Monday 26 September).

The coronal hole forecast comprises just one feature: Ch25/+. Connection to this feature - if indeed this has occurred - is more fickle than anticipated, with speeds in the range of 400-450km/s currently observed, and indeed now hinted at by STEREO A PLASTIC measurements (although there are significant data gaps due to regular eclipses around the equinox). The chances of G2 occurring are now considered Slight at best, while the risk of G1 has also been moderated significantly. There remains a risk of G1s surviving into ay two, Saturday 24 September, although this is also suitably reduced and is more likely to manifest at Earth earlier rather than later in the UTC day.

The CME forecast is much more complex. Coronagraph imagery is significantly clouded in recent days by numerous small emissions, periodically rendered more inconvenient for analysis by data gaps in triangulating STEREO A imagery. The current best estimate involves up to two Earth-bound CMEs.

Firstly, a slow CME seen late in the UTC day of 21 September leaving the southeastern quadrant, with no ascertained source, but most likely from AR3105.

Secondly, a more assured CME release seen heading mainly north and west of the Sun-Earth line from late in the UTC morning on Lasco C2. The source of this second CME is likely to be the rapid emergence of AR3109, however the precise emission time is more speculative, with several small dimmings in AIA 211 that could be progenitors.

Of the above two CMEs, the second carries a more confident Earth-bound trajectory (although still with significant uncertainty). Current MOSWOC Enlil solutions maintain these two CMEs as distinct features (just) with arrivals late in the UTC of 25 September and around the turn of the UTC day of 26 September. These CME should serve to prolong the tail of risk from the coronal hole fast wind from CH25/+, probably seeing out Monday 26 with a Chance of G1 before abating after the end of this four-day forecast period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	20	10	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/0532	Partial	Inferred SE disc, perhaps AR3105	SE disc	309	Late 25 Sep	Source uncertain, very low confidence. Probably independent from later CME
22/2058	Partial	Inferred AR3109	Centre NW disc	400	26/0100UTC	Inferred source, low confidence, mainly N and W of Sun-Earth line.

Figure 2: Latest MOSWOC Enlil run and accompanying ensemble, showing closely-spaced incident CMEs late on 25 September and into the start of 26 September. The distinction is perhaps best seen by comparing the density spikes between STEREO A, B and Earth, with the Earth trace implying that the later CME is the more impactful (with the earlier spike almost absent from the deterministic run). Confidence for both is low, but especially the former.

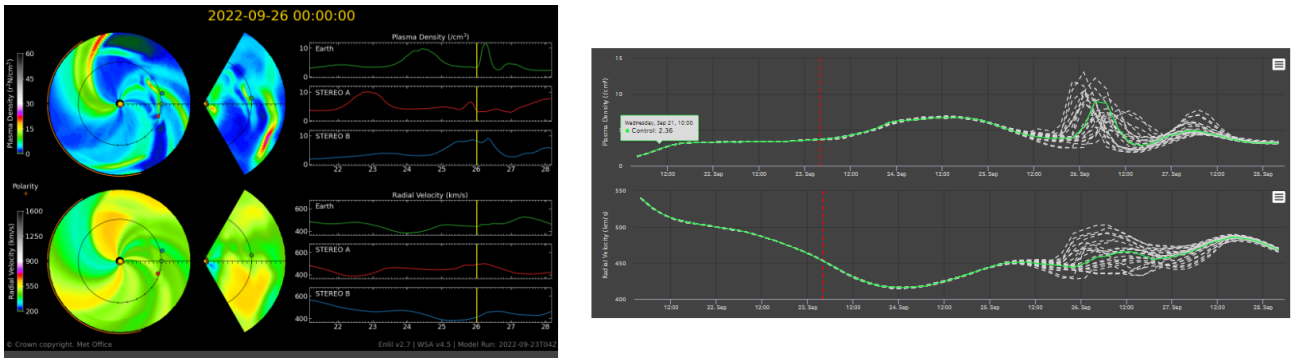
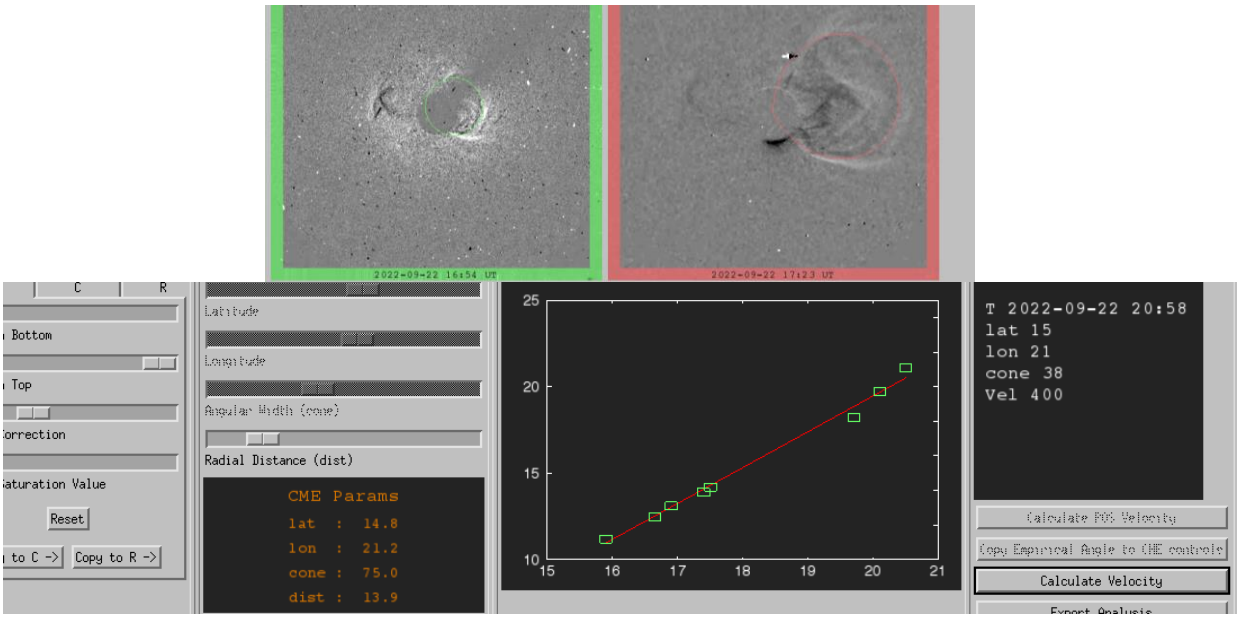


Figure 3: contributory 22 September CME analysis using NOAA SWPC CAT tool. Shown are Lasco C3 difference imagery perspectives (green) and STEREO A (red)



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Radio Blackouts - X-Ray Flares:

There are currently five numbered sunspot regions on the visible disc, now joined by a potential sixth near the northeastern limb.

The largest and most complex group remains AR3105 in the southeast, on the cusp of Dkc/Ekc Zurich designation, and now with a candidate for a small delta spot in its intermediate portion. Despite its appearances, it remains the case that this group has undr-delivered compared to similar groups in the historical records, perhaps because of its presumed age, or its hitherto simple Beta classification.

Also of note on the disc is the possible CME-producing AR3109, which emerged rapidly after midweek UTC but has since stalled at Cri/Beta classification, with gradual emergence of a new trailing spot the only recent change. Other groups on the disc were less noteworthy, with more stable behaviours.

The far side appears to be populated by numerous large regions of at least plage according to recent soundings, with these arriving in succession into the next working week, to be assessed as and when they materialise over the limb.

All considered, there is a daily Chance of M-class flares, revised down from raw values for the current disc to better match observed activity.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	40	40	40	40
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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Figure 4: AIA171 imagery and 24-hour difference imagery of HMIIF, showing relative sizes of the current cohort of sunspots now (black) with 24 hours previously (white).

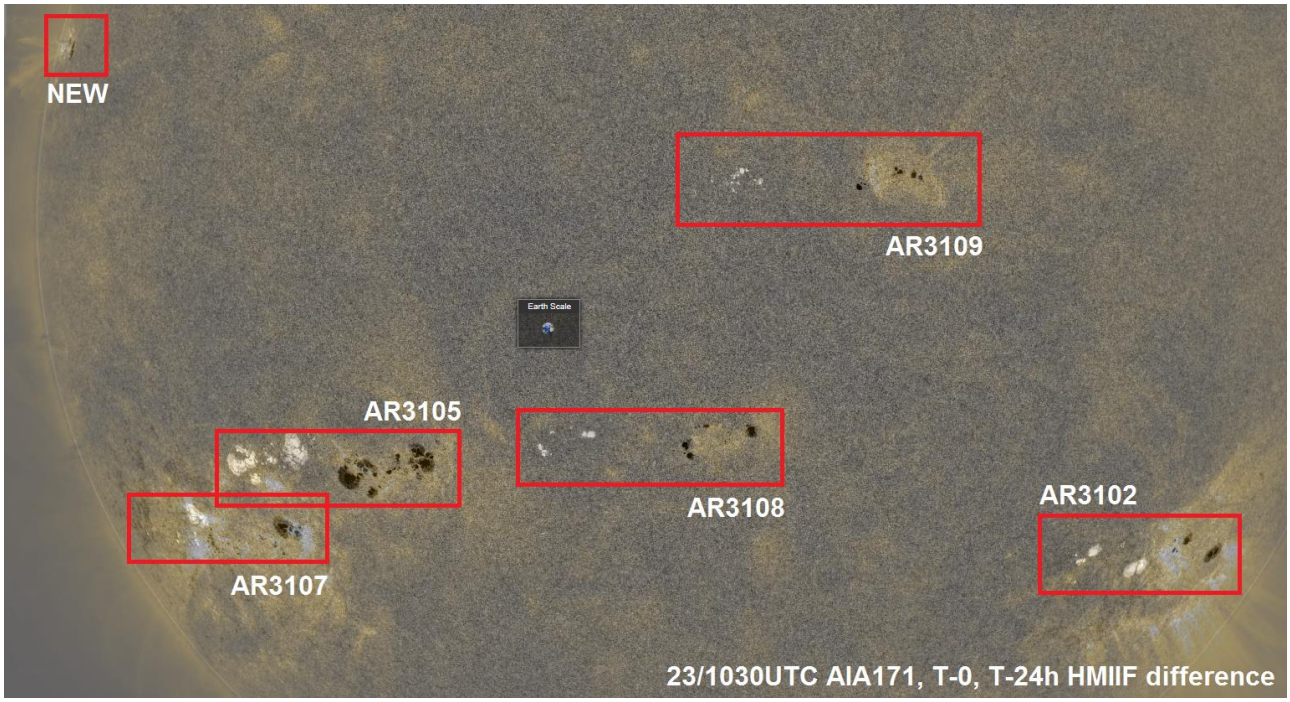
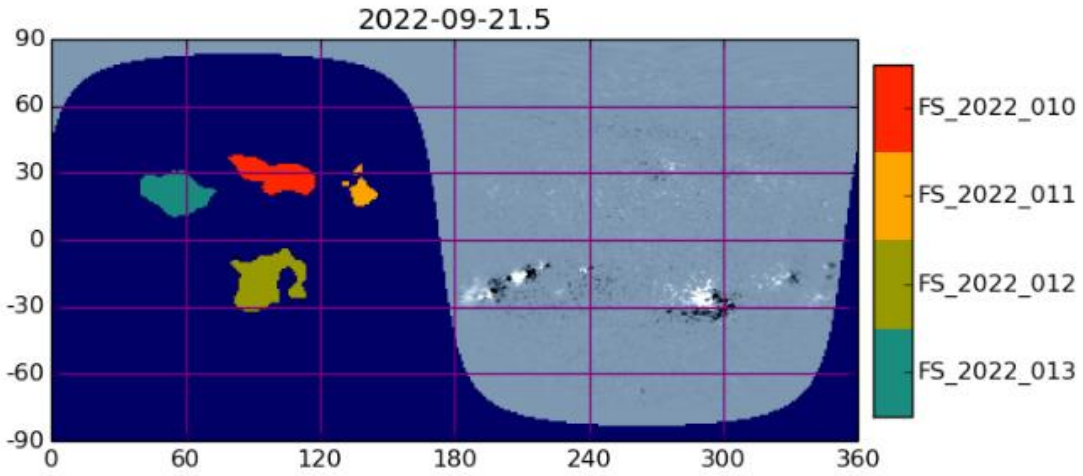


Figure 5: Far-side sounding of the Sun, showing potential active regions due into next week.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) observed by GOES16 is expected to remain at or very close to Background levels. The main flare risk sunspots currently populate the southeastern disc, however their gradual westward transit will see an overall slight increase in the risk of S1+ in the period, with AR3105 probably offering the most significant contribution.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	5	5
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2 MeV) as observed by GOES16, is currently in the Normal Background to Moderate range.

The arrival of the fast wind of CH25/+ today is expected to enhance electron populations at Earth, with High flux levels perhaps developing during days three and four (25 and 26 September) once initial geomagnetic activity subsides. Confidence in this occurring is now dented by the possible pollution of the final two days of the period by faint partial halo CMEs - one from 21 September and one from 22 September, with the latter the more likely to be impactful, perhaps sweeping up its forerunning sibling in a united front.

The associated 24-hour fluence is expected to stay below the Active (1e8 integrated pfu) threshold through most the period, but possibly rising above for a time in the possible lull between CH25/+'s incidence and any later CMEs.

MOSWOC REFM is not considered useful in the above scenario, given differences in CH25/+'s appearance to last pass and the presence of up to two transients later in the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	20	40	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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